Early Childhood Science Technology and Engineering Standards

Practices, Crosscutting Ideas, Disciplinary Core ideas

Draft
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The State of Massachusetts is in the process of developing a new set of standards for science, technology, and engineering to replace the current framework. Pre-K standards detailing desired outcomes for children by the time they leave pre-school at age 4 to enter kindergarten are to be part of the State standards. This document is a draft of those standards as well as the practices and crosscutting ideas. It is designed to be easily integrated with and feed into the K-12 standards. The document is divided into three sections reflecting the likely structure of the new Pre-K-12 standards. Dimensions 1 and Dimension 2 are descriptions of practices and ideas that are integrated into the standards themselves that are found in Dimension 3.

The practices, ideas and subject matter standards detailed below are to be used as guides for the development and implementation of challenging and appropriate learning experiences for children. This document is neither a checklist nor a curriculum. It does not imply that science/technology and engineering are to be isolated and taught directly. Rather the ideas and practices detailed here are to be integrated into the lives of children in the classroom in ways that will support the development of the children's abilities, dispositions, and understanding.

Dimension 1 Scientific and Engineering Practices

This dimension identifies the skills and thinking we expect children to use and develop when they engage in science inquiry, plan and build things, and design solutions to engineering problems. Some of the practices come naturally to children as they play; many need the encouragement and guidance of an adult. Young children use all of these as they explore and investigate in science, as they design a solution to a problem, and as they play. They use many of these in other domains as well including mathematics. These skills and ways of thinking are learned more deeply and more meaningfully in authentic contexts and not when they are practiced individually or in isolation.

Children demonstrate these practices when they

- Ask questions and solve problems/design things (engineering)
  - Display curiosity
  - Observe and ask questions about observable phenomena (objects, organisms or events)
  - Identify a problem/something to be designed that can be constructed first hand (engineering)

- Plan and carry out investigations
  - Draw on prior knowledge and experience to predict what might happen and inform investigations
  - Plan and implement investigations using simple equipment; design/build a solution to a problem
  - Use senses and simple tools to observe, gather, and record data (e.g., dictate, draw, photograph, write)
- Make meaning from experience and data
  - Describe in many ways what happened during an investigation or in building (engineering)
  - Talk and think about (reflect on) what happened during an investigation or in solving a problem and why what happened might have happened
- Use mathematics and computational thinking
  - Count and measure using non-standard and standard units and learn to use standard units when appropriate to support STE understanding
  -Use mathematical language to describe attributes such as position (*next to*), motion (*backwards*), speed (*fast*), shape (*circle*), size (*tall*).
- Construct explanations/theories and evaluate solutions (engineering)
  - Construct theories based in experience about what might be going on
  - Look for and describe patterns and relationships
  - Use evidence to support a theory or solution (engineering)
- Develop and use models
  As children try to make sense of their experiences, adults can guide them in representing their ideas in many ways – drawing, modeling in clay, making a collage – and using these to help develop explanations of their experiences.
  - Represent, (e.g., draw, use blocks, use clay, make a collage) findings
  - Use simple models to develop explanations
- Engage in discussion/ argument from evidence
  - Engage in discussion before, during and after investigations
  - Support thinking with evidence
- Obtain, evaluate, and talk about information
  - Document experiences and thinking to communicate with others
  - Use basic science and engineering terms and vocabulary
  - Use first hand interactions with objects and organisms, media, and books to gather information

Dimension 2: Crosscutting Concepts

The crosscutting concepts have application across all domains of science as well as in other subjects. They provide one way of connecting ideas across the science domains in Dimension 3 as well as in other subjects. These are not explicitly taught, rather they guide teachers in their interactions with children as they explore and investigate.

For young children this means guiding them to look for

- Patterns: Recognize, classify, and record patterns (e.g. apparent movement of the sun, life cycles, weather)
- Cause and effect: Identify cause and effect in events, relationships and patterns, (e.g. light and shadows, force and moving things, temperature and melting ice; forces and building collapse.)
- Systems: Investigate accessible and visible systems in nature and human made things; describe things in terms of parts, roles of parts, relationship among parts (e.g. life cycle of a plant, blocks in a block building.)
- Structure and Function: Investigate how things work; reflect on characteristics parts and what they do (e.g. shape of a duck's foot/swim, properties of a tree trunk /stability) and human-built world (e.g. design of a building/stability, shape of a fork/eat.)
- Stability and change: Explore and reflect on events and things that change and those that stay the same (e.g. buildings that stand and those that fall, melting, freezing, growth of living things, seasons, apparent motion of the sun (seasons and seasonal change, apparent motion of sun and moon).

Dimension 3: Disciplinary Core and Component Ideas

The disciplinary core and component ideas reflect content in the physical, life, and earth and space sciences that is developmentally appropriate for young children and that they can explore through direct experience. It also is content about which they are likely to have and be able to develop ideas and theories. The ideas for this age level provide a foundation in experience and inquiry for later years. They are designed to guide the selection and focus of learning experiences for children. The core ideas are divided into life, earth and space, and physical science in order to present them more clearly, however in the classroom these ideas will be integrated with one another in various ways and also will be explored through children's daily work and play.

It is important to note that young children may hold or develop naïve and scientifically inaccurate theories due to lack of experience, delight in fantasy, and/or immature reasoning skills. It is critical for children to come up with their own ideas, and in many cases it is appropriate to acknowledge their reasoning and accept these naïve ideas. As they gain more experience and develop their reasoning powers over the years, they will adjust these ideas to conform more closely to those accepted in science, technology, and engineering.

What follows are the core and component ideas in each area of science (in the boxes) and the outcome standards – that is what we would expect young children to know and be able to do as they enter kindergarten. The standards include the crosscutting concepts in brackets where appropriate and relevant. There also are suggestions for integration with mathematical ideas as well as engineering practices and ideas after each major section. There are no explicit connections to literacy because of the pervasiveness of language in science teaching and learning. As they do science, children talk about their work in small

and large groups and learn new vocabulary and sentence structures. They regularly document and record their work in many different ways. They use books and other media to find information, expand their experience, and enjoy stories related to the work they are doing.

Core and Component Ideas in the Life Sciences

LS1/3: From Molecules to organisms: Inheritance and variation of traits

- Plants and animals have external parts that they use in different ways to survive, grow and reproduce.
- Animals use their 5 senses to gather information about the world around them.

Standards

Children who demonstrate understanding can

A. *Describe/draw and compare the body parts of animals (including themselves) and plants they are investigating [System] and explain functions of some of the observable body parts. [Structure and Function]*
B. *B. Identify the 5 senses as ways animals (including themselves) gather different kinds of information about the world around them. [Structure and Function]*
C. *C. Use their senses in their exploration and play to gather information. [Structure and Function]*
D. *Recognize stages of the life cycle of plants and animal they have observed and discuss ideas about what happens at each stage. [Patterns, Change]*
E. *Describe differences and similarities between young animals and their parents*
F. *Identify similarities and differences among individuals of the same species [Patterns]*

Mathematics connections

As they interact with the living world children have many opportunities to use mathematics to help them describe what they are seeing. They use the language of size (*large, small*), shape (*round, oval*), and weight (*heavy, light)* and use numbers as part of the description of an organism (*number of legs, body parts.)* Children compare living things by attribute. They measure sizes of plants and animals (including themselves) as they grow and develop They begin to recognize sequence and pattern as they observe life cycles of organisms (*first comes the caterpillar, then the chrysalis*).. Children construct graphs charting growth rate over time and use the graphs to describe the changes that take place.

Technology and engineering connections

As children interact with the living world there are many opportunities to engage in problem solving, use tools, and engage in engineering practices. They use magnifiers and measurement tools to study organisms. They may build an indoor environment for a small creature or a feeder for birds. They may design and build a support for their growing plants. They also may think about the designed world as they compare the homes of local animals to their own and the gardens outside their school.

LS2/4: Ecosystems; Biological Evolution

- Living things grow and reproduce and need energy.
- Living things depend on their surroundings to meet their needs.
- Different plants and animals meet their needs in different places because their specific needs vary.

Standards

Children who demonstrate understanding can

A. Use evidence to define several characteristics of living things that distinguish them from non-living things [Patterns]

B. Using their experiences in the local environment and other evidence, raise and discuss questions about the basic needs of familiar organisms and how they might meet their needs. (Clarification statement: Basic needs include water, food, air, shelter, and light for most plants)

C. Investigate local environments and infer/imagine how some living things might meet basic needs. [Structure and Function; Cause and Effect]

D. Determine the variety of living things in a local area and characteristics of the places where they were found.

E. Predict where they might find a familiar plant or animal and explain why they think so based on experience and knowledge of the organism. [Patterns]

Mathematics connections

As they begin to connect living things with the environments in which they live, children begin to notice the resources available to support living things. They use comparative language to describe quantities and make connections (*enough water, there are more ants where it is drier, and more worms where it is wet.)* Children count the numbers of living things they find in their local environment, compare quantity (*more ants than worms*), and count the number of legs on an animal or leaves on a new plant.

Technology and engineering connections\

As children interact with the living world there are many opportunities to engage in problem solving, use tools, and engage in engineering practices.

They use magnifiers and measurement tools to study organisms. They may build an indoor environment for a small creature or a feeder for birds. They may design and build a support for their growing plants. They also may think about the designed world as they compare the homes of local animals to their own and the gardens outside their school.

Core and Component Ideas in the Earth and Space Sciences

ESS1: Earth's place in the Universe

- There are natural objects visible in the sky including the sun, moon, stars, clouds and human made objects including airplanes, kites.
- The moon can be seen in the sky at different times of the day and night and in different places and it appears to change shape.
- The sun appears to move across the sky during the day and sets in the evening.

Standards

Children who demonstrate understanding can

A. Observe and describe objects in the day and (if possible) the night sky

B. Describe different apparent shapes of the moon they have seen and demonstrate awareness that the moon can be seen in the daytime and at night [Patterns]

C. Observe and use evidence to explain that sun and the moon are in different places in the sky at different times. [Patterns, Systems]

Mathematics connections

As children engage in exploration of the sun and the moon, they document and discuss their observations and look for meaningful patterns in what they see developing their skills in sequencing and identifying patterns. They also use mathematical language as they describe the moon's apparent shape at different times including the language of fractions.

Technology and engineering connections

As children engage in exploration of the sun and moon and objects in the sky, they are introduced, through books and other media to some of the tools that people use including binoculars and telescopes. Their play may involve the design and construction of model space crafts and tools for space exploration.

ESS2: Earth's Systems

- Natural non-living materials and objects that are present in the environment include rocks, soil, water, and sand.
- There are many human made materials and objects in the environment
- Water is found in many places including oceans, lakes, rivers, and ponds

Standards

Children who demonstrate understanding can

*A. Observe, investigate and classify the non-living materials, natural and human made, in their environment (*Technology progression as well.)*

B. Raise questions and engage in discussions about how different types of local environments (including water) provide homes for different kinds of living things.

C. Explore and describe the different places water is found in the local environment

Mathematics connections

As children investigate the non-living environment, they compare, sort, and classify non-living materials they find using size and shape as two characteristics. They map where things and conditions may be found using language of distance and direction.

Technology and engineering connections

As children investigate non-living materials and objects, they identify what is human made. They think about materials and what they can be used for. In their play they design and build with natural resources such as sand, dirt, rocks, and branches as well as human made objects such as blocks and tires. Children also use tools such as magnifiers for closer examination and shovels to dig.

ESS2: Earth's Systems

- Weather is the combination of sunlight, wind, rain or snow, and temperature
- People measure and record weather using simple tools.
- Weather changes from day to day and week to week

Standards

Children who demonstrate understanding can

E. Use simple instruments to collect and record data on elements of daily weather. [Patterns] (Clarification Statement: Elements of weather can include sunlight, wind, rain, and temperature.) [Patterns]

F. Use data to describe how local weather changes from day to day and over the seasons and recognize patterns in those changes. [Change]

G. Apply their ideas about weather in their play (Clarification statement: Make connections between what they wear and can do and the weather.)

Mathematics connections

As children gather data about weather, they use their knowledge of number and their ability to compare quantity. They count sunny days and rainy ones. They measure rainfall and wind speed. They create and use simple charts and graphs to look for patterns.

Technology and engineering connections

As children study weather they use many simple tools including thermometers rand in gauges. In their play, they may model the work of meteorologist. As they think about

the implications of different seasons, they talk about the clothes we wear and the houses we live in.

ESS3: Earth and Human Activity
Standards
Children who demonstrate understanding can

A. *Engage in discussion and raise questions using examples about how humans use local resources (e.g., soil, water) to meet their needs [Cause and Effect]*
B. *Observe and discuss the impact of people's activities on the local environment [Cause and Effect]*

Mathematics connections
As children explore the use of resources such as building materials playgrounds they may use mathematical language to describe what they see.

Technology and engineering connections
As children explore how local resources are used they may use them themselves to design and build something such as a fort in a fallen tree or a dam in a stream or run-off.

Core and Component Ideas in Physical Sciences

PS1: Matter and its interactions: Structure and properties of matter

- Objects and materials can be described and classified based on their physical properties, uses, and whether it is natural or manufactured
- Objects have some properties that are different from the properties of the materials of which they are made.
- Objects and materials can change and be changed in many different ways including, breaking apart, mixing with other things, changing state.,
- Some materials in the environment can change from liquid to solid and back again.

Standards
Children who demonstrate understanding can

A. *Describe, compare, sort and classify objects based on observable physical characteristics, uses, and whether it is manufactured as part of their classroom play and investigations of the natural and human-made world.*
B. *Differentiate between the properties of an object and those of the material of which it is made in science explorations and activities such as art and music.*

C. *Raise questions about the differences between liquids and solids and use their experiences to share ideas about how a liquid might become a solid and vice versa [Stability and Change, Cause and Effect]*

D. *Investigate and give examples from experience of how objects and materials can change including breaking apart, mixing, or changing state [Cause and Effect, Stability and Change]*

Mathematics connections

When children gather data on the properties of matter, they use mathematical language. They describe and compare objects in terms of shape, size and volume. They use non-standard or standard units to measure height, width, and length. They measure liquids in terms of volume and amount. The use of this mathematical language supports the understanding of matter's various properties.

Technology and engineering connections

As children plan and build things in their play, they determine what materials and objects to use based on their properties. They select different size and shape blocks to build a tall tower; they pick a box for the front of their model train.

PS2: Motion and stability; Forces and interaction

- Pushing and pulling an object changes the speed or direction of an object or make it stop
- Bigger or smaller pushes or pulls makes things go faster or slower
- Structures are pulled down unless the design and materials of the structure keeps it in place

Standards

Children who demonstrate understanding can

A. *Plan and carry out investigations of the behaviors of moving things*

B. *Using evidence, discuss ideas about what is making something move the way it does and how some movements can be controlled. [Cause and Effect, Stability and Change]*

C. *C. Explore the strength and stability of buildings as they build structures with different materials [Cause and Effect, Stability and Change]*

Mathematics connections

As children investigate forces and motion they use mathematical language to describe and compare how strong a force it is that is making something move. They may measure how far something goes down a ramp or a slide, or how quickly things drop such as parachutes or feathers. They measure the size and the weight of the cars they are racing or the balls rolling down ramps.

Technology and engineering connections

As children explore force and motion, they are continuously engaged in planning and building and problem solving. They make ramps for rolling things, they make kites and parachutes to fly, and they make cars to roll.

PS4: Energy and PS4

- Different objects and materials make different sounds
- The pitch and volume of a sound can be changed in different ways (e.g. more or less tension of a surface or string, more force used to make the sound)
- If an object blocks light from a light source, there is a shadow
- The size and shape of a shadow depends on a number of things (e.g. the size, shape, and orientation of the object; where the light source is; and the distances from light source and the object and the object and the shadow.
- Some materials let light go through them, others only let some light through, and some materials let no light through them

Standards

Children who demonstrate understanding can

A. Investigate different sounds made by different objects and different materials and reason about what is making the sounds [Cause and Effect]

B. Apply their understanding in their play of how to change volume and pitch of some sounds.

C. Through investigation and using daily experience construct ideas about the relationships between the size and shape of shadows, the objects creating the shadow and the light source. (Pattern, Cause and Effect)

D. Compare and sort materials into those that allow all, some, or no light to pass though them (Cause and Effect,)

Mathematics connections

As children investigate sound, they measure the size of an object that is making the sound. They think about how far away a sound is and the direction it is coming from. They compare sounds busing terms such as more or less and louder and sifter. – louder and softer.

As children explore light and shadow they make shadows bigger and smaller measuring and comparing. They change the shapes of shadows and describe what they see. They compare how far away a light source is and even the angle at which light shines on an object or bounces off a mirror.

Technology and engineering connections

As children engage in exploring light and sound, they design and build musical instruments, string telephones, shadow boxes, and shadow puppets.